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EVALUATION OF A CONTROLLED RELEASE FORMULATION OF METHYL-CYCLOHEXENONE (MCH) IN PREVENTING SPRUCE BEETLE ATTACKS IN ALASKA

U.S. Department of Agriculture
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ABSTRACT

A controlled release formulation of the anti-aggregation pheromone, MCH, was tested at three dosage rates (6.9, 9.2, and 11.5 kg/ha) for prevention of spruce beetle attacks in felled white spruce near Granite Creek, Alaska. There were no significant differences between treated trees and felled check trees. Factors affecting expected release rates are discussed.

# INTRODUCTION

The spruce beetle, Dendroctonus rufipennis, is the most destructive pest of white, Picea glauca, and Sitka spruce, P. sitchensis, in south-central and southeast Alaska (Werner et al. 1977). Infestations presently cover 170,316 hectares, of which 22,182 hectares occur on the Chugach National Forest, specifically the Kenai Peninsula (Anon. 1985). These outbreaks are believed to have resulted from windthrown trees in slash from seismic line, power line, road rights-of-way, and from improper timber harvesting methods (Werner and Holsten 1983).

Several control techniques are recommended for suppression of spruce beetle populations (Averill 1978; Holsten 1981, 1982; Werner et al. 1977; Werner 1978; Gibson 1984). These techniques include the immediate salvage of infested trees in conjunction with trap trees, insecticide treatments (Werner et al. 1983, 1984), and use of attractant baited traps to reduce beetle populations. These techniques are adequate where infestations are accessible.

Another technique is the use of synthetic anti-aggregant compounds to prevent attack or reduce the attack density to a level below the threshold density required for the development of brood trees. This type of strategy has several advantages. First, ground access to treatment areas is not necessary since aerial application of a treatment formulation might be possible. Secondly, beetle resistance to treatment, with time, would not be likely since brood development would be prevented. Lastly, there would be no direct mortality to parasites and predators as occurs with many insecticide treatments. Likewise, due to the nature of anti-aggregants, environmental impacts would be minimal.

3-methyl-2-cyclohexen-1-one (MCH) has been shown to be the anti-aggregant pheromone of both the Douglas-fir beetle (D. pseudotsugae) and the spruce beetle (Rudinsky et al. 1974; Kline et al. 1974; Furniss et al. 1976; McGregor et al. 1984). Recently, a granular controlled-release formulation of MCH was aerially applied to 76.9 hectares of uninfested Douglas-fir (Pseudotsugae menziesii) and Englemann spruce (P. engelmanni) in Idaho. The treatment resulted in a 94.6% reduction in Douglas-fir beetle infestations and reduced spruce beetle attacks by 55% (McGregor et al. 1984).

MCH has been experimentally tried in Alaska with varying results. A liquid controlled release formulation of MCH repressed spruce beetle attraction to synthetic and natural attractants by 99% and 87%, respectively in tests conducted on the Kenai National Wildlife Refuge (Furniss et al. 1976). However, a similar study conducted the following year showed that MCH was ineffective in preventing spruce beetle attacks (Furniss et al. 1979). MCH was again tested in Alaska in 1983 (Holsten and Werner 1984). Liquid and granular controlled release formulations of MCH were tested at three dosages each. The best granular treatment (9.2 kg/ha) reduced beetle attacks and progeny by 70% and 61%, respectively when compared to the untreated controls.

Results of a MCH field study initiated in the spring of 1984 to determine the efficacy of three dosage rates of formulated controlled release MCH for protecting felled, uninfested white spruce from beetle attack are presented in this paper.

## MATERIALS AND METHODS

Study Site: The field test was conducted in a white spruce stand along Granite Creek on the Chugach National Forest in south-central Alaska (latitude 60°45'N, longitude 149°15'W). This area is composed of mature white spruce mixed with white and black spruce (P. mariana) seedlings and saplings. Average diameter and height of the dominant and co-dominant spruce used in the study were 40.8 cm and 20.2 m, respectively. Beetle populations were endemic in the study area (< 2% attacks on standing spruce), but heavily infested spruce stands were approximately 8 km from the study site.

Treatments: The experimental design was a completely randomized block with four treatments each replicated five times. Twenty uninfested white spruce were felled in early May along a north-south transect. Each tree was felled in a east-west direction and was at least 30 m from the next down tree. Air temperature and relative humidity were recorded hourly on a Belfort® hygrothermograph placed at the midpoint of the transect. Precipitation, collected in a standard rain gauge, was recorded weekly.

As previously mentioned, our best 1983 dosage of formulated MCH was 9.2 kg/ha. We decided to bracket this dosage in order to "fine tune" it. Accordingly, treatments consisted of a granular controlled release formulation (98% inert, 2% MCH)[1] applied at rates of 6.9, 9.2, and 11.5 kg/ha. A 4.6 kg/ha dosage was reported to have an elution rate of 0.25-2.5 gms MCH/ha/day which was the best for a 90%+ reduction of Douglas-fir beetle attacks (Furniss et al. 1981). Thus, our dosage rates should minimally elute at 0.38, 0.50, and 0.63 gms MCH/ha/day; effective for 30-60 day period. MCH granules were applied along the top of the felled trees on May 10 with a hand operated fertilizer spreader. Felled, uninfested check trees received no treatments.

The elution rate of the granular MCH formulation at the 9.2 kg/ha dosage was determined in the laboratory and the field. Laboratory elution rates were determined in a controlled environment of 21°C and 50% relative humidity for 32 days. Field elution rates were determined in the following manner: ten, 15x15x1.3 cm hardware cloth cages containing enough formulated MCH to equal the 9.2 kg/ha dosage were randomly scattered on the forest floor near the Granite Creek study area on May 10. Five packets were randomly retrieved at three and four weeks. The packets were then placed in plastic bags and refridgerated until final weighing.

Treatment Evaluation: Bark samples were taken from each tree at 1 m from the cut bole in early September. Bark samples were 0.5 m-wide bands around the circumference of the bole. Each bark sample was evaluated for treatment efficacy as follows: (1) number of beetle attacks per $m^2$; (2) number and mean gallery length per $m^2$; and (3) number and stage of beetle brood per $m^2$.

Analysis: Variables were subjected to a one-way analysis of variance (ANOV). Data were transformed, if necessary, by $y = \sqrt{x + 3/8}$ to overcome variations due to zero counts which were expected to exist in the treated trees. Duncan's Multiple Comparison Test of the means was undertaken.

[1] Formulation received from M. McGregor, Coop. Forestry and Pest Management, Missoula, MT.

## RESULTS AND DISCUSSION

Favorable temperatures for beetle flight first occurred on May 12, but only for a short time (Fig. 1). Peak beetle flight probably occurred during the first two weeks of June as substantiated by other studies on the Kenai Peninsula[1]. Seventy-five percent of the sampled trees contained one-year life cycle spruce beetles.

The results of the treatment evaluation are presented in Table I. At first glance, there appears to be a treatment effect (e.g. a reduction) in all variables evaluated. However, the ANOV showed that there were no significant differences ($p < .05$) between treated and untreated controls. This was a result of the significant variation in beetle response to the treatments (Table I).

One explanation for this lack of control is the variability and lower than expected release rate of the formulation. The laboratory determined elution rate showed an average loss of 3.7 gm MCH/ha/day which falls within the optimal rate (0.5-5.0 gm/ha/day) determined in the 1983 study (Holsten and Werner 1984). However, the variation around this mean was $\pm$ 5.3 gm/ha/day, demonstrating that the elution rate was anything but constant. The field elution rate was shown to be approximately 1.81 gm MCH/ha/day for 32 days; 51% less than the laboratory rate. However, the three-week weighing showed that the field formulation eluted an average of 2.3 gms MCH/ha/day; 22% more than the four-week re-weigh. As the field MCH formulation was only weighed twice (3 and 4 weeks), we have no idea of the daily variability of release rates as shown in the laboratory study but assume it approaches it. The micro-climatic conditions of the forest floor and duff layer in Alaska appear to be such (cooler) that they retard the elution of MCH which was originally formulated to function under Idaho and Montana conditions.

We did, however, achieve a significant reduction (70%) in attack levels in our 1983 study. One difference between the studies was the use of two different "batches" of formulated MCH. There might have been a difference either in the polymers used or the level of MCH. However, we did not undertake an analysis of the formulation which was successfully used in Idaho in 1984[2]. Likewise, we experienced "heavier" beetle flight and attack densities in 1984 than 1983. Control trees received approximately 40.2 attacks/$m^2$ in 1984 vs. 29.1 attacks/$m^2$ in 1983. This 29% increase in attack density might have resulted in higher production of natural aggregating pheromones which in turn "overwhelmed" any anti-aggregant effects of the treatments.

Before further MCH field studies are undertaken in Alaska, more research is needed to "tailor-make" a formulation that will adequately elute MCH based on our climatic conditions. The field elution rate of MCH might have to be doubled or tripeled to be effective against the spruce beetle in Alaska[3].

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[1] J. Hard, Personal Communication, Anchorage, AK., 1984

[2] M. McGregor, Personal Communication, 1984

[3] Mal Furniss, Personal Communication, 1984

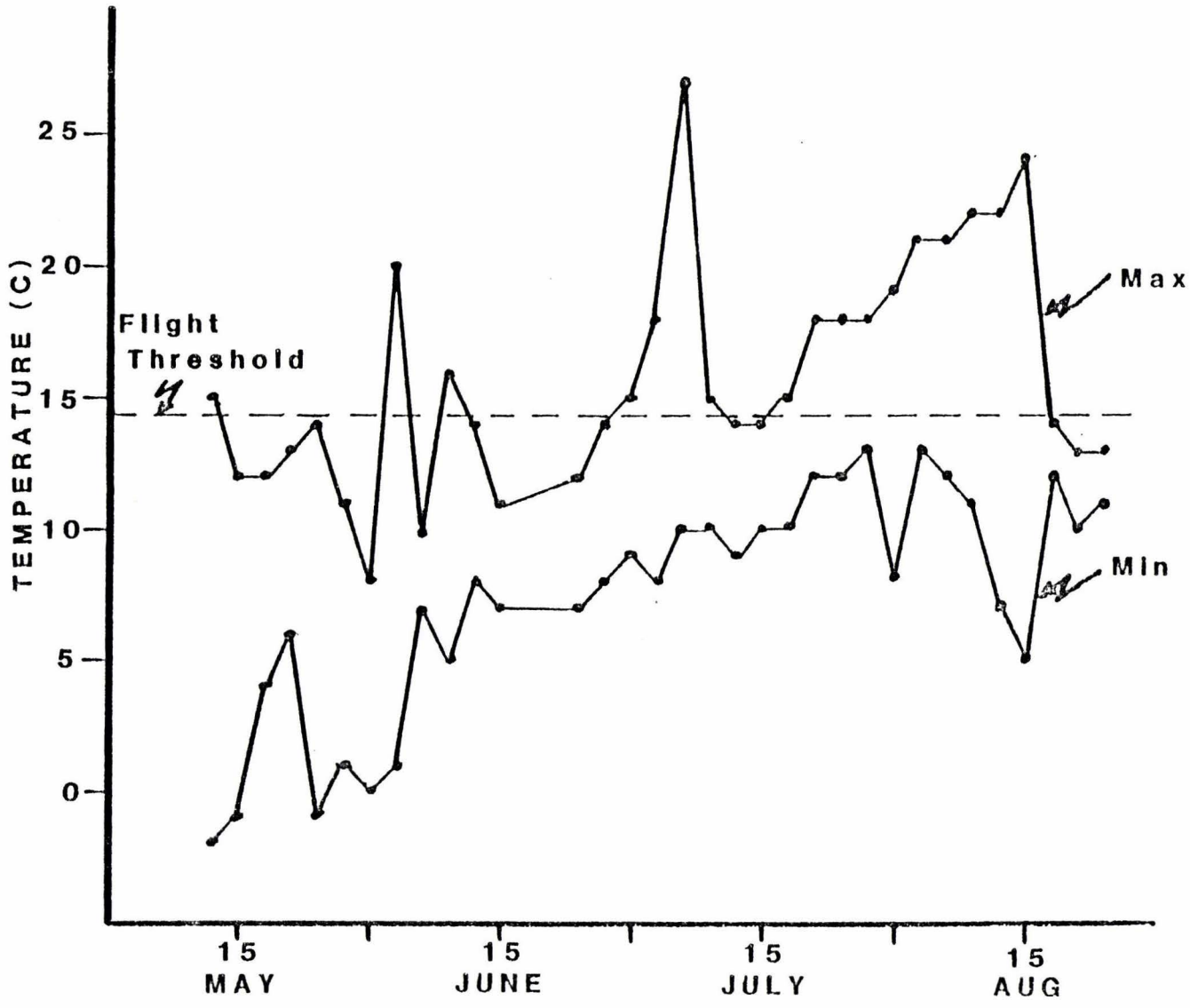


Fig. 1. AVERAGE DAILY MAXIMUM AND MINIMUM TEMPERATURES AT GRANITE CREEK AS RELATED TO FLIGHT THRESHOLD TEMPERATURE FOR SPRUCE BEETLES.

Table I. Average number per $m^2$ of spruce beetle attacks, galleries, progeny, and gallery length by treatment.

| Treatment | No. of trees | Av. no. attacks | Av. no. galleries | Av. no. progeny | Av. gallery length(cm) |
|---|---|---|---|---|---|
| CRF[1] 6.9 kg/ha | 5 | $27.8 \pm 16.3^{a}$[2] | $43.1 \pm 20.2^{a}$ | $447.3 \pm 220.2^{a}$ | $10.4 \pm 1.6^{a}$ |
| CRF 9.2 kg/ha | 5 | $24.4 \pm 14.9^{a}$ | $44.7 \pm 30.6^{a}$ | $517 \pm 580.9^{a}$ | $8.7 \pm 5.3^{a}$ |
| CRF 11.5 kg/ha | 5 | $25.7 \pm 23.2^{a}$ | $39.8 \pm 28.9^{a}$ | $686.9 \pm 662.2^{a}$ | $13.6 \pm 5.4^{a}$ |
| CONTROL | 5 | $40.2 \pm 15.2^{a}$ | $75.8 \pm 22.6^{a}$ | $1028.3 \pm 630.2^{a}$ | $10.1 \pm 1.4^{a}$ |

[1]Controlled release formulation

[2]Numbers in the same column followed by the same letters are not significantly different ($p < .05$, Duncan's Multiple Comparison Test)

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